

Targeting climate change adaptation strategies to small-scale private forest owners[☆]



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A B S T R A C T

Climate change adaptation needs to receive extensive attention in the forestry sector. While measures are being applied in federal forests and large private properties, it remains unclear how small-scale private forest owners, with a property < 20 ha, perceive the possible influence of climate change and whether they will approach required activities. While in the past, the majority of private forest owners had ties to agriculture and cultivated farmland alongside their forests, recent studies revealed new trends and significant deviations from established norms and beliefs. Therefore, this study aimed to investigate the motivations for forest ownership, current management practices, and perception of and adaptability to climate change, to discuss successful approaches for information campaigns, advisory services, and monetary incentives. The study applied a questionnaire with an embedded choice experiment, which obtained a thorough understanding of the salient factors influencing decision-making by surveying 919 forest owners across Austria. Results show that small-scale private forest owners are not homogenous. Three distinct segments were identified (utility oriented, recreation oriented, and tradition conscious forest owners) which reacted differently to provided management options and incentives. However, even under a worst-case scenario setting, 84% of forest owners would select some sort of management over no procedure, indicating that forest management is not generally rejected. Information campaigns should rather focus on soft management leading to attractive, stable and highly diverse forest stands resilient to climate change than on cost efficiency and financial benefits. Therefore, advisory services need to convey, that all forest measures are performed with special care and under consideration of the remaining forest and that each stand is treated individually with adequate equipment. Increasing monetary incentives, such as funding, barely influences forest owners' decision-making and are therefore deemed unfeasible and unable to motivate the owners to undertake climate change adaptation measures. The study shows that a segmentation based on management behavior and preferences rather than on predefined characteristics has the potential to define a new state of the art. Overall, climate change adaptation through tailored forest management is highly supported by the presented findings.

1. Introduction

With close to 48% coverage and rising, Austria is one of the most wooded countries in Europe (BMLFUW, 2007). In addition to its economic (76%) and protective (20.5%) function, forests provide a multitude of ecosystem services such as recreation and tourism (BMLFUW, 2007; BFW, 2010). Hence, it is of great importance and societal relevance that future climate change impacts receive extensive attention in the forestry sector. Even under the assumption of a moderate climate change scenario, the probability of summer droughts and heat waves is likely to increase considerably (Luterbacher et al., 2004; Schär et al.,

2004). These expected abiotic impacts may further interrelate with biotic effects such as changing pathogen and pest regimes. To a minor extend, this interaction has already occurred over the past 15 years, as Norway spruce stands in Switzerland and Austria experienced severe bark beetle infestations, mostly triggered by storm damages and favored by the increasing temperatures of the recent decade. Multiple studies indicate that particularly Austria's mountain forests will be sensitive to changes in climatic conditions. While the growth rate at higher elevations with sufficient water availability will increase as a result of an extended growing season, especially coniferous forests may suffer under those ever-increasing biotic impacts (Krehan and Steyrer,

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2005; Ammer et al., 2006; Dobbertin and DeVries, 2008). Effects will also be severe in secondary spruce forests at the Alps' foothills, as drought prone areas will suffer from bark beetle influx and decreased productivity (Führer et al., 2006; EFI, 2008; Bolte and Degen, 2010; Lexer et al., 2014). A reduced productivity will particularly affect forests in the eastern and north-eastern lowlands and the inner-alpine basins. Considering the economic interrelations with other sectors, these developments would result in the gross national product decreasing by an annual average rate of 463 million € by 2065 (Lexer et al., 2015).

Climate vulnerability is not purely determined by ecological processes such as draughts or bark beetle outbreaks, but is additionally influenced by the adaptive capacity of the forest owners. Many factors shape the owners' adaptive capacity including the ownership structure (e.g. small-, medium-, large-scale forests, public or private units), manifested management traditions and decision-making structures, societal trends and value changes, availability of forest sector labor, climate change awareness, recent experiences, training, and education (EFI, 2008; Pröbstl-Haider et al., 2016a,b). As rotation periods of typically 60 years or more need to be considered, long-term, far-sighted, and targeted adaptation strategies and measures will be necessary to sustain forest functions and services at desired levels in the upcoming decades (Garcia-Gonzalo et al., 2008; Seidl et al., 2011; Seidl and Lexer, 2011; Pülzl et al., 2013). Consequently, to enhance climate change adaptation in forest management, a coupled social-ecological system perspective is crucial (Liu et al., 2007; Rammer and Seidl, 2015).

For the adaptation process in Austria, the socio-economic component is of high relevance as forests are predominantly managed by private forest owners (82%) and the ownership structure is characterized by small-scaled properties with an average size of < 10 ha (9.2 Hectare per unit) (BMLFUW, 2015; Waldwissen.net).

While in the past, the majority of private forest owners had ties to agriculture and cultivated land alongside their forests, current Austrian- and European-wide studies revealed new trends and significant deviations of those new small-scale private forest owners from established beliefs. The increasing, so-called “new” forest owners hold smaller and more scattered units, which are further divided between children when bequeathed, their ownership begins late in life (in their 60s), their forests do not have an economic function and do not participate in the timber market as timber mobilization does not play a significant role on their small units and they are engaged in other professions, forest management is therefore not part of their land use anymore, and they have little to no experience in forest management and few forest related skills (Hogl et al., 2003; Kvarda, 2004; Hogl et al., 2005; Weiss et al., 2007; Suda et al., 2013; Weiss et al., 2015; Živojinović et al., 2015). While climate change adaptation measures are already being applied in federal forests and by some private large-scale forest owners, adaptation strategies remain unknown for the new small-scale private forest owners (Seidl and Lexer, 2011). In addition, as those forest owners are not easily reached through traditional forestry information channels it is unclear, if these owners are aware of climate change and how they will approach the required activities for adaptation and sustainable forest management. Those uncertainties demand more in-depth research concerning small-scale private forest owners' awareness and perception of and adaptability to climate change and provide the opportunity to discuss the means to influence small-scale forest owners' forest management decision-making and to enhance the likelihood of their adoption of adaptation strategies.

2. Theoretical background and study objectives

2.1. Forest management by small-scale private forest owners

Forest owners are not homogenous and in addition subject to continuous transformation due to ongoing demographic and societal changes such as recent significant, structural changes in land-use (Hogl

et al., 2005; Weiss et al., 2007). The research in the past decade revealed that these changes lead to new types of forest owners with altered attitudes, management practices, forest related values, and overall goals (e.g. Kvarda, 2004; Hogl et al., 2005; Boon and Meilby, 2007; Weiss et al., 2007; Suda et al., 2013; Lidestav et al., 2015; Živojinović et al., 2015). The new forest owners were found to (jointly) own sub-divided, small-scale forests and are believed to be silviculturally alienated, residing outside of their forest property, with little or no involvement in forest management (Lidestav et al., 2015; Weiss et al., 2015).

Compared to large-scale enterprises, management tasks in smaller forest units differ in their dimensions, costs of implementation, and revenue. Therefore, management experience and demands established in state or large-scaled private forest units can rarely be transferred to owners of smaller-scaled forests. In the French context, Normandin (1996) emphasizes that most private forests owners do not follow the proper logic of forest enterprises. Anderson (2011) shows that, in Sweden, owner and property characteristics have a significant influence on management decisions. Novais and Canadas (2010) investigated management logics of private forest owners in Portugal, who are responsible for 73% of the Portuguese forest area. The authors point out that knowing the circumstances and logic behind owners' actions is crucial to understand the technical and environmental content of their forest practices and to design the solutions and policies that will secure sustainable forest management. For Austria, Weiss et al. (2015) describe an increasing trend to passive management behavior with possible negative implications for the timber and paper industry, wood energy production, ecosystem services, and climate change adaptation.

So far, climate change adaptation by means of appropriate forestry measures received little attention by and lacks action of forest managers across Europe (Blennow et al., 2012; Eriksson, 2014; Lisdkog and Sjödin, 2014; Wagner et al., 2014; Matilainen et al., 2015). The main reasons for a low willingness to adapt are diverse and include a short-term economic orientation of the forest owners, the small size of their forest unit, conflicts with nature conservation, uncertainties regarding future conditions (time horizon), knowledge gaps and a low perception of possible risks. The willingness slightly increased when negative changes became visible. Recent investigations of the German and Austrian forestry sector either as a whole or through interviews with forestry workers in small samples (Matthes et al., 2014; Seidl et al., 2016) observed a willingness to spread risks through mixed forests. Hence, a certain degree of adaptation disposition can be assumed. Those findings imply, that forest management and its policies need to be altered, to fit the needs, interests, and abilities of new owners and increase their willingness to conduct measures and increase adaptability.

Despite these findings, several authors still emphasize considerable research deficits concerning the responses of private forest owners to climate change (Moser and Ekstrom, 2010; Seidl et al., 2016; Pröbstl-Haider et al., 2017).

2.2. Socio-economic adaptive capacity of the forest sector

Climate change adaptation might either be achieved by keeping or changing forest composition and structures (Bolte et al., 2009). Many publications have discussed suitable adaptation strategies for forest management facing climate change (e.g. Noss, 2001; Kellomäki et al., 2005; Zebisch et al., 2005; Lindner et al., 2010; Lexer et al., 2014). Spittlehouse and Stewart (2003) developed a framework of short and long-term adaptation actions that are directed towards impacts and vulnerabilities. A European wide expert survey (EFI, 2008) identified three groups of adaptation motives: (1) minimizing impacts of disturbances, (2) ensuring wood production, and (3) ecosystem services. Furthermore, the authors defined four action levels (stand, forest management, policy and research level) and interlinked specific short- and long-term adaptation actions. The average forest owner is only

Adaptation measures	On-going measures	Planned measures
Forest regeneration (selection of tree species or provenance better adapted or adaptable to the changing climatic conditions)	• Select indigenous tree species and provenances • Select tree species that perform well across sites • Select tree species that can develop into stable diversified forests • Mix different tree species, provenances and genotypes	Use more natural regeneration Select tree species and provenances that are more resistant to temperature extremes Select fast-growing tree species
Tending and thinning (frequency and intensity of treatment after establishment or regeneration and before final harvest)	• Change silvicultural systems and thinning intensity to reduce risks of abiotic disturbances • Forbid thinning or change silvicultural systems in special conditions (e.g. risk of erosion rock fall or avalanches) • Change thinning methods for mixed and multistory forests	Change thinning schedule and intensity to decrease risks of abiotic disturbances Change thinning schedule for biomass harvesting Use specific management for the forest edges to avoid risks of abiotic disturbances Change management of stand for more stable and diverse stand structure Change thinning intensity in the most sensitive areas
Harvesting	• Modify harvesting procedures • Improve harvest equipment and tools for wet conditions • Use small-scale cutting areas • Execute sustainable harvesting	Prefer selective cutting

Fig. 1. Adaptation measures on the stand level (changed after [EFI, 2008](#)).

likely to make decisions on the stand level by influencing forest regeneration, stand tending, thinning and harvesting. [Fig. 1](#) summarizes the on-going and planned adaptation measures a forest owner may take into account on the stand level ([EFI, 2008](#)).

Overall these strategies assume a broad apprehension of a stress resistant and resilient state of a forest ecosystem at a given environmental location and suggest adaptive strategies depending on aspects such as forest structure, age, species composition, exposition, forest functions to achieve this state. In the context of Austrian forests, most recommendations for climate change adaptation are rather conservative, as typically represent no-regret strategies such as a slight increase in tree species and structural diversity of forests and an enlarged vigilance towards biotic and abiotic stressors ([Seidl et al., 2011](#); [Brang et al., 2014](#)). Highly impacting scenarios like a profound change in tree species composition are avidly rejected in wide parts of Europe ([Hanewinkel et al., 2012](#)).

Despite a large body of literature advising forest decision makers on climate change, adaptation remains a challenge as the topic seems difficult to communicate to practitioners, particularly when they are no forestry experts ([Lindner et al., 2010](#)). Overall, three main strategies are discussed to increase the willingness to adapt:

- information and information campaigns (e.g. [waldwissen.net](#); [proholz.at](#)),
- advisory services (e.g. [Weiss et al., 2010](#)), and
- payments or subsidies for ecosystem services (e.g. [Prokofieva, 2016](#)).

Forest authorities, forest services, and timber industry undertake considerable efforts to reach and inform forest owners. However, the

group of small-scale private forest owners is particularly difficult to inform, as traditional forest channels barely reach them, extension services have little to no contact ([Weiss et al., 2015](#)), and (land-use based) inventories usually do not cover their properties. Therefore, information campaigns are challenging to implement.

Based on expert interviews, [Weiss et al. \(2010\)](#) concluded, that the main solution applied in policy practice is the implementation of enhanced advisory services. Forest owners can receive advice and educational support from experts of the provincial authorities, the Austrian Chamber of Agriculture, the Austrian Federal Forests service unit, regional and local forest enterprises and forest management units.

The third strategy is well established and addresses payments for ecosystem services (PES) or a particular management measure (i.e. climate change adaptation measures), which generates the desired ecosystem services ([Prokofieva, 2016](#)). PES may be received through advisory services, forest authorities, or the chamber of agriculture. Already existing subsidies are provided for forest management planning, harvesting, and wood marketing. However, as [Prokofieva \(2016\)](#) and [Bennett and Gosnell \(2015\)](#) point out, the design and implementation of payments for environmental services are complex tasks that require the understanding of the whole array of socio-ecological components, apart from the general contextual settings.

Therefore, this study aims to

- explore the compilation, characteristics, and main ownership motivations of small-scale private forest owners in Austria,
- understand their perception of climate change and possible consequences for their forests,
- identify typical socio-economic and ecological trade-offs and barriers for climate change adaptation, and

- examine strategies to guide small-scale forest owners' forest management decision-making and to enhance the likelihood of their adoption of adaptation strategies.

3. Method

3.1. Study design

The basic concept for this study was a simulation of the decision-making process of a small-scale private forest owner in Austria, who is confronted with information concerning forest manage, incentives, and various management issues. In order to develop suitable management strategies for these owners, it is essential to understand what influences their decision-making more: the current financial and ecological situation or the desired outcome for the next generation. For research on trade-offs and decision-making the choice experiment is a well-established method. In contrast to other applicable methodologies (e.g. Theory of Planned Behavior (Ajzen, 1985, 1991)), this modeling approach focuses directly on intended behavior, which has become possible with the advent of more sophisticated multivariate statistical techniques such as the multinomial logit model. Choice experiments has many advantages compared to other approaches.

Surveys based on a choice experiment,

- prevent the risk of a strategic response and thereby increase the reliability of the response (van Beukering et al., 2007).
- allow a differentiated understanding of choice decisions between different attributes (Adamovic et al., 1998a, 1998b),
- enhance the consideration of hypothetical states, possibilities, and “non-use values” (van Beukering et al., 2007, Adamovic et al., 1998a, 1998b), and
- improve the investigation of risks and uncertainties, particularly in regard to climate change (Pröbstl-Haider and Haider, 2013, Pröbstl-Haider et al., 2016a,b).

Therefore, a questionnaire with an imbedded choice experiment was chosen as the most appropriate method to analyze small-scale private forest owners' climate change perceptions, ownership motivations, current forest management strategies and preferences for adaptation measures. The target of the tailor-made survey included all Austrian small-scale private forest owners who owned up to 20 ha.

In order to increase understanding of and knowledge about the new small-scale private forest owners, the survey included 27 open- and closed-ended questions (i.e. multiple-choice, dichotomous, rating scale, and ordinal scale questions) investigating participants' forests, owner's perception of climate change, their motivation for forest ownership, and socio demographics. The choice experiment aimed to obtained a thorough understanding of the salient factors influencing the decision making of private forest owners. The questionnaire was designed for online and paper-based application and was pre-tested by experts and non-specialists before distribution to ensure functionality, clarity, and ease of use.

3.2. Choice experiment (CE henceforth)

Owners' preferences for management strategies depend on a multitude of influencing factors such as the type of procedure, its cost and impact on the forest, or the commissioner of the procedure. However, not all of these aspects are equally important to all owners. When selecting a management strategy, owners are confronted with a multivariate decision problem. Selecting the preferred strategy requires them to simultaneously contemplate multiple aspects of the strategies at hand and trade-off the individual aspects of one with aspects of the others according to their preferences. This intricate decision making process requires an appropriate methodological approach, which allows for the analysis of participants' preferences for and willingness to make specific

trade-offs. Individuals are thought to relentlessly strive for decisions which maximize their utility and their relative satisfaction (Louviere et al., 2010). Therefore, in the practical application of CEs, respondents are asked to repeatedly evaluate a set of two or more hypothetical “scenarios”, comprised of attributes with multiple levels, and to consistently select the preferred alternative - the one providing them the highest overall utility. Rather than evaluating one separate trait after another, participants take all attributes into account and reveal the trade-offs between different attributes within the choice task they are willing to make when picking one scenario over another [$U_a > U_b$] (Louviere et al., 2010; Train, 2003). However, since an objective measure of all potential choice set arrangements is essentially impossible, the full utility of scenario a is defined as the sum of the measurable (V_a) and immeasurable (ϵ_a) components [$(U_a) = V_a + \epsilon_a$] (McFadden, 1974). The probability of selecting scenario a can then be described as the exponent of all measurable elements of alternative a over the sum of the exponent of all measurable elements of alternative b [$\text{Prob}\{\text{choosing } a\} = e^{V_a} / \sum e^{V_b}$]. This coherence allows the subsequent definition of the use-value of every single attribute and its levels of the CE. Through this allocation, the probability of a specific scenario as a function of its attributes and the attributes of all compared options can be determined (i.e. with the help of a decision support tool), providing significant information to decision-makers based on participants' actual preferences.

Based on the EFI suggestions, respondents were introduced to a specific situation at the stand level and presented with potential adaptation measures addressing forest regeneration, thinning, and harvesting equipment. The situation is typical for secondary spruce forests in lowlands and sub-montane regions in Austria. The CE asked participants to imagine that they own 1 ha (10,000 m²) of a 40-year-old forest dominated by coniferous trees with a few deciduous trees (10%). Since climate change may lead to negative impacts on this forest (such as draught stress, bark beetle) the forest administration suggests increasing the number of deciduous trees. The participants' task was to select the one management scenarios they would prefer to be applied in their forest. The three hypothetical management scenarios consisted of seven attributes grouped into the “Current decision”, which included monetary attributes, the management type and the service provider commissioned, and the “Condition in 50 years”, which illustrated the long-term consequence of the chosen management procedure (Fig. 2). Dividing the scenarios into these two sections allowed for an evaluation of the long- and short-term orientation of the owners.

The three management scenarios included a conservative adaptation strategy, which increases the diversity without additional or foreign tree species, a highly impacting scenario with a profound change in tree species composition, and no procedure. In the high impact procedure, an increase in tree species diversity is perceived as the best solution to cope with climate change. Since a successful natural regeneration of the desired tree species is impossible, thinning is combined with the afforestation of additional deciduous trees. Hence, the costs are higher than for the soft measure. Despite the opening in the canopy structure leading to temporarily vulnerable stands, the strong measure is thought to be the safest strategy to minimize the risk of future damages. The proposed soft measure would remove approximately 25% of the trees and would purely be based on natural regeneration. The tree species diversity is not optimized to the expected extent of climate change, but will increase the stability of the forest as compared to a “do-nothing approach” (no procedure).

The seven attributes and their alternative specific levels which describe the possible measures and outcomes were created and refined based on a thorough literature review of past and present research concerning forest management evaluation and of international forest owner surveys, expert opinion gathered through continuous bilateral exchanges, two stakeholder meetings in the two test regions with up to twenty participants, twelve key informant interviews, and ongoing focus group sessions of the project team. Attributes and their associated

		ALTERNATIVE A	ALTERNATIVE B	ALTERNATIVE C
Current decision	Intensity of procedure	Soft procedure predominantly natural regeneration	Strong procedure predominantly regeneration through planting	No procedure
	Balance after procedure	500 €	1,000 €	---
	Funding	5,000 €	5,000 €	---
	Type of procedure	Tractor	Tractor	---
	Commissioned by	Regional or local forest enterprise	Regional or local forest enterprise	---
Condition in 50 years	Probability of climate change induced damages	Very low	Low	High
	Potential change in value (estimate baseline 40.000 €)	0%	0%	0%
	Amount of deciduous trees	20% deciduous trees	40% deciduous trees	3% deciduous trees

Fig. 2. Example of one choice task projecting management strategies for a soft (A) and a strong procedure (B). Alternative C only depicts the condition in 50 years as no procedure is performed.

Intensity of procedure	Soft procedure predominantly natural regeneration	Strong procedure predominantly regeneration through planting	No procedure
Balance after procedure	- 500 € +/- 0 € + 500 €	- 1.000 € +/- 0 € + 1.000 €	---
Funding	1.000 € 2.000 € 5.000 €	1.000 € 2.000 € 5.000 €	---
Type of procedure	• Harvester • Tractor • Manual operation	• Harvester • Tractor	---
Commissioned by	• Regional or local forest enterprise • Environmental organization • Forest management units • Service Team or Austrian Forest Service	• Regional or local forest enterprise • Environmental organization • Forest management units • Service Team or Austrian Forest Service	---
Probability of climate change induced damages	Very low	Low	High
Potential change in value (estimate baseline 40.000 €)	+ 10 % 0 % - 5 %	+ 10 % 0 % - 10 %	+/- 0 % - 10 % - 20 %
Amount of deciduous trees	10 % 10 % 20 %	20 % 30 % 40 %	0 % 1 % 3 %

Fig. 3. All attributes and their associated levels applied in the choice experiment. The presented choice task consisted of certain combinations of these levels.

levels are depicted in Fig. 3.

The attribute BALANCE AFTER THE PROCEDURE projects three monetary values indicating either a gain, a zero balance or a loss generated through the selected procedure. The gain and loss for the strong procedure are higher than for the soft procedure, which requires less work, retrieves less timber, and will consequently generate less revenue. This attribute does not apply for the no procedure scenario.

The Austrian Ministry for Agriculture, Forestry, Environment and Water Management (BMLFUW) provides a subsidy up to 100% of the eligible investment costs (at least 500 € expenses) through the Special Directive on the implementation of project measures under the Austrian Rural Development Program 2014–2020. However, the attribute

FUNDING projects values much higher than current achievable subsidies for the predefined forest area in order to understand the relevance of financial incentives.

The TYPE OF PROCEDURE is correlated with the intensity of the procedure. Manual operation is only feasible for the soft and omitted in the strong management scenario.

The soft and the strong procedure require the commissioning of a service provider (COMMISSIONED BY). Besides regional and local forest enterprises, the Austrian Federal Forests service and forest management units (“Waldpflegegemeinschaften”) are frequently commissioned. This study also introduced environmental organizations as alternative option which hardly exist at the moment.

The PROBABILITY OF CLIMATE CHANGE INDUCED DAMAGES is a fixed variable and the first attribute describing the condition of the forest in 50 years. If no procedures are set, climate change is highly likely to negatively impact the forest. The probability decreases to low and very low for the soft and strong procedure respectively. This distinction is due to a higher degree of natural resilience remaining in “less disturbed” forest environments. A strong procedure may disrupt the ecosystem, leaving it more vulnerable to climate change impacts.

The POTENTIAL CHANGE IN VALUE indicates an in- or decrease of the forests worth in 50 years. Due to a lesser disturbance through the soft procedure, the maximum loss of value is set at – 5%, while for the strong procedure – 10% was selected. For the no procedure scenario, no increase in value is assumed and the maximal impairment is – 20%.

As the AMOUNT OF DECIDUOUS TREES influences the long-term stability and reduces the susceptibility of forests to disturbances in changing climatic conditions, this attribute aims to indicate overall success of the procedure. The attribute indicates the percentage of deciduous in the future forest, which is set at a minimum increase of 10% in the soft and 20% in the strong procedure. Through a soft procedure, a maximum of 20% deciduous trees may be achieved, while a strong procedure may result in a 40% share. If no procedure is performed, deciduous trees may still emerge naturally, yet to a significantly lower degree (1% or 3%).

The three hypothetical management scenarios were created and combined into the alternative specific choice sets through an orthogonal fractional factorial design produced in SAS using a ‘mktex’ macro (Deff 87.186, Aeff 74.5357, Geff 97.4772, APSE 0.9718). The design plan contained 54 choice sets. One respondent evaluated six randomly chosen choice sets.

3.3. Data collection and analyses

The online questionnaire was available from January to May 2015. As the targeted small-scale private forest owners are barely reached through traditional information channels, greater efforts had to be made to increase participation. The Austrian Ministry for Agriculture, Forestry, Environment and Water Management (BMLFUW) supplied addresses of 10,000 small-scale private forest owners, which were then contacted, informed about the project, and personally invited by the Federal Research and Training Centre for Forests, Natural Hazards and Landscape through a mailer. The Forest Owner Union of Styria and the Forest Organization Department of the Tyrolean government invited their associated small-scale private forest owners through mailers and announcements in their bimonthly newspapers. Furthermore, several public bodies (the BFW, the University of Natural Resources and Life Sciences Vienna (BOKU), and the Environment Agency of Austria (UBA)) were asked to send email invitations to staff, researchers, and associates and encouraged them to participate in the survey as long as they owned 20 ha forest or less. Due to the sampling method, a non-response bias could be preempted. As the total number of Austrian small-scale private forest owners is unclear, no reliable information on the response rate can be provided.

Collected data was analyzed in IBM SPSS Statistics 21, the CE in Latent Gold 5.0 through executing a Latent Gold Choice model. To relax homogeneity assumptions and account for unobserved heterogeneity, a latent class model (LC) was applied. The LC resulted in separate, comparable models, in which estimates were compared across classes through Wald(=) statistics. Finally, the latent gold and LC model with the model best fit (based on the significance of the output and BIC, AIC, and AIC3 values) were selected and used to design a decision support tool (DST). The DST enables the analysis for diverse management strategies and their effects on the participants based on their preferences indicated in the CE. No comparison of the collected sample to

general data on forest owners holding < 20 ha could be made as the available administrative data purely contains information on larger units.

4. Results

4.1. Overall results

A total of 953 small-scale private forest owners participated in the questionnaire. Due to erratic response behavior in the choice experiment, 34 participants were excluded from the analyses. Of the remaining 919 about half (54.2%) were recruited through the addresses of the BMLFW, 27.9% by the Forest Owner Union of Styria and the Forest Organization Department, and 17.9% by public bodies (BFW, BOKU, and UBA). Participants showed an equal spatial distribution across Austrian regions.

The average small-scale private forest owner in this study can be described as male (80.3%), between 26 and 56 years old (66.4%; range 20 to 85), with a high level of education (42.2% college, 29.3% skilled trade, 19.3% high school certificate). They possess between 0.1 and 5 ha (66.0%) by themselves (69.1%), which are divided into four unconnected lots (range 1 to 27 lots). The forests were inherited (78.7%), purchased.

(23.2%) or received as a gift (5.1%) approximately 13.3 years (range 1 to 85 years) ago. Over 57% reported mixed stands, 41.2% coniferous, and 12.5% deciduous forests. The age structure was dominated by middle-aged (84.4%) and mature forests (81.3%), while young stands are less frequent (74.9%). The average owner lives in rural areas (77.3%; 8.3% in larger cities) and < 5 km away from the forest (71.1%). Probably due to this close proximity, almost 97% of the forest owners had visited their forest in the past year. Concerning future ownership, most participants (78.3%) do not intend to either sell or purchase forest within the next five years. Only one third of respondents (33.1%) is member of a forest owner association.

In general, small-scale private forest owners agree with most emotional motives and ranked the majority of these statements almost equally. A good feeling, family tradition, and the contribution to the natural landscape are the most important motives for forest ownership. Social aspects were of lesser relevance. Participants differentiated more strictly when rating economic motives, conceiving collecting firewood for personal use, and bequeathing and owning a property of stable value as important.

Climate change is a fairly well-known issue among small-scale private forest owners. Approximately half of all participants believe in climate change (56.8%), its impact on their forest (50.3%) and that adaptation measures need to be implemented as soon as possible (52.0%), while 20% consistently reject the idea of climate change (16.0% are undecided and 2.9% do not believe in it), its impacts (20.6%), and the necessity of adaptation measures (22.7%). In addition, about 19.6% of participants indicate that they “do not know” if measures are necessary.

In general, forest owners do not consider forest maintenance a burden. Most participants agree they tend to apply gentle measures and that they keep their forests in groomed and tidy states. Most participants (89.3%) have tended to their forest in the past five years. Out of these owners, 82.6% performed the measures themselves, 12.3% had a friend or neighbor maintaining their forest, 10.1% commissioned an agricultural service contractor, and 6.2% a silvicultural service contractor. Owners who did not apply management measures state a lack of necessity for such measures (44.6%), time constraints (44.6%), lack of consultation (16.9%), financial reasons (10.8%), and ecological reasons (7.2%) as driving factors. The majority of forest owners is interested in stable mixed-species stands that are carefully tended.

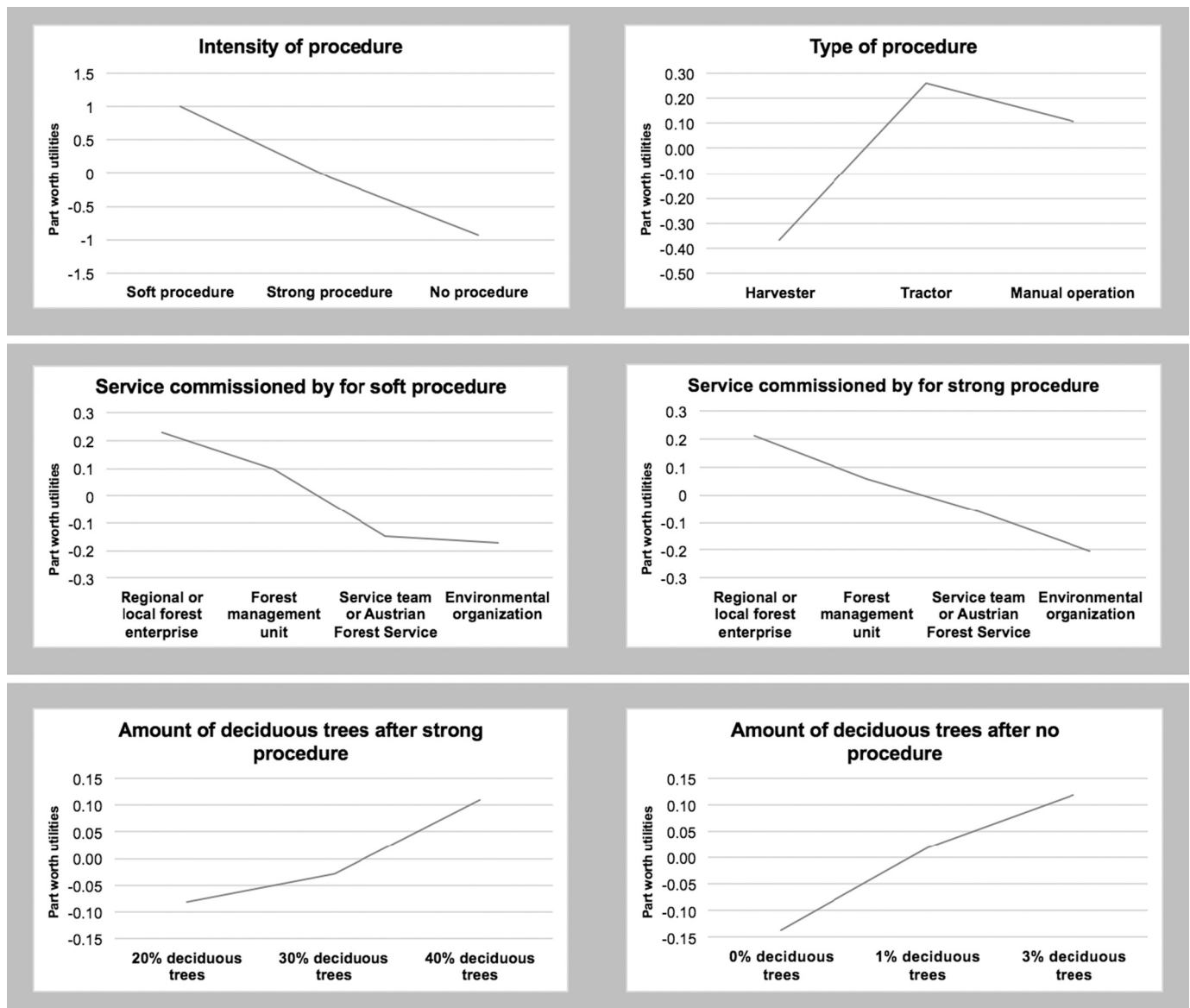


Fig. 4. Selected part worth utilities of the one class choice model (all participants). The slopes depict the utility participants gain from the individual levels of each attribute. Higher, positive utilities have a positive impact on participants' choice, while levels with negative or low utility are less preferred in a management strategy.

4.2. Analysis and results of the CE

4.2.1. Overall preferences

The initial analysis revealed that forest owners favor a soft over a strong or no procedure (graph “Intensity of procedure”) and in addition a softer implementation though tractors instead of harvesters (graph “Type of procedure”). Regional or local forest contractors are strongly preferred compared to environmental organizations and the Austrian Federal Forests service (graphs “Service commissioned by”). Monetary factors, such as funding, the balance after the procedure, and the potential change in value of the forest show clear, expected trends towards obtaining a positive balance, the largest amount of funding and the least loss in value. Further, the owners indicated a positive utility from more deciduous trees. This is particularly visible for the no procedure option (graphs “Amount of deciduous trees”). The six respective graphs projecting the part-worth utilities of those attributes are depicted in

Fig. 4. Part-worth utilities for all attributes are shown in [Appendix 1](#).

4.2.2. Latent class segmentation

The subsequent latent class model (LC) indicated considerable unobserved heterogeneity and the model fit improved from the conditional logit model. The analyses revealed three distinct segments of forest owners: (LC 1) utility oriented, (LC 2) recreation oriented, and (LC 3) tradition-conscious forest owners. The three classes differed significantly in multiple aspects including socio-demographics, ownership motivation and climate change perception (Fig. 5).

The CE revealed that LC 1, the utility oriented forest owners/lovers (59.2% of sample), is characterized by individuals strongly supporting soft management procedures and techniques. In particular harvesters have a severe negative impact on these owners' utility. Preferences exist for the commissioning of regional or local forest enterprises and forest management units. The Austrian Federal Forests service is rejected as

	The utility-oriented forest owner/lover	The recreation-oriented forest owner	The tradition-conscious forest owner
Size of class	59.2%	30.1%	8.7%
Forest visits	Frequent visits	Frequent visits	Few visits
Size of forest	Average size of forest is larger than in other segments	High amount of small-scale forest units	Small-scale forest units
Type of forest	Highest amount of more productive spruce forests	High amount of deciduous forest	High amount of deciduous forest
Emotional motives	Social contacts are important (neighbourhood)	Conservation, forests are important for recreation and meaningful leisure time	Family tradition is most important motive
Economic motives	Additional income is somewhat relevant	Inheritance of valuable units	Inheritance of valuable units
Residency	Mainly from rural areas	Mainly from larger cities	Mainly from rural areas
Climate change	Expect effects on their forests later on	See first signs of climate change and expect impacts	Do not believe in effects of climate change or impacts on forests
Respondents	About 20% female	Least amount of female respondents	High amount of female respondents
Education	Well educated	Highly educated	Less educated

Fig. 5. Description of and differences between latent classes.

service provider and environmental organizations generate the highest negative utility of all suppliers. The class shows support, yet not a strong preference, for an increase of deciduous trees. Monetary attributes do not project strong utility estimates, indicating a low importance.

Owners in LC 2 (30.1% of sample) accept more intensive management actions but tend to be highly particular concerning the service provider commissioned. The only organization accepted for a soft procedure are regional or local forest enterprises, while for the strong procedure forest management units may also be approved. Environmental organizations and the Austrian Federal Forests service are strongly rejected. Undertaking procedures with a harvester strictly generates negative utility. The group retrieves a greater utility from a larger share of deciduous trees in their forests.

The tradition conscious forest owner (LC 3, 8.7% of sample) refuses most interventions and only considers alternatives in case of high financial losses. The preferred organizations are regional and local forest enterprises and forest management units, while the other two are strictly rejected in the soft and environmental organizations additionally accepted in the strong procedure. The use of harvesters is the least preferred type of procedure. Monetary attributes such as funding only influence their utility positively under the highest level (see [Appendix 2](#)).

4.3. Strategies to enhance climate change adaptation in small-scale private forests

If the forest section of the Austrian Ministry for Agriculture, Forestry, Environment and Water Management (BMLUFW) was to decide to enhance small-scale private forest owners' climate change adaptation through information campaigns, specific advisory services, or new subsidies as suggested by several authors, the CE may provide crucial guidance for their implementation. Based on the effects of attribute alteration on owners' preferences, preferred and rejected

scenarios can be discussed in more detail and the results can aid in the investigation of adaptation barriers. In addition, the true image of management actions or service providers in the public can be analyzed.

This section will firstly provide crucial aspects related to a potential information campaign, secondly project the main issue in the context of a tailor-made advisory service, and thirdly portray the likely effects of financial incentives. Although these aspects are presented separately, it needs to be underlined that they are highly interlinked and related.

In order to analyze the relevance of the individual attributes and their trade-offs on management decisions, the decision support tool (DST) was used. The interface of the DST was designed after the choice experiment, in which all levels of all attributes could be altered individually, thereby creating different management strategies. The upper section of the DST projects the selected scenario, while the lower section shows the preferred management strategy (in % of participants selecting this option) of all participants ("All owners") and the three latent classes (utility oriented forest owners/lovers, recreation oriented forest owners, and tradition conscious forest owners).

4.4. Key issues regarding information campaigns

Any information campaign must consider the overall trend and basic disposition of small-scale private forest owners and the preferences of their respective segment. A valuable insight can be provided by looking at the worst-case scenario. [Fig. 6](#) projects the preferences of all forest owners and the individual segments when the lowest levels or correspondingly the highly-disliked attributes apply. In this case, the owner has no financial gain, forest tending occurs with unfavorable service providers and equipment, and the situation in 50 years promises anything but losses and a minor increase in deciduous trees. Under such circumstances the majority of forest owners would decide in favor of a soft procedure (64%). This scenario also aids to understand the basic disposition and preferences of the three owner segments. While the vast majority of utility oriented forest owners (86%) choose the soft and

		Forest management scenario		
Current decision	Intensity of procedure	Soft procedure predominantly natural regeneration	Strong procedure predominantly regeneration through planting	No procedure
	Balance after procedure	-500 €	-1,000 €	---
	Funding	1,000 €	1,000 €	---
	Type of procedure	Harvester	Harvester	---
	Commissioned by	Service Team or Austrian Forest Service	Service Team or Austrian Forest Service	---
Condition in 50 years	Probability of climate change induced damages	Very low	Low	High
	Potential change in value (estimate baseline 40.000 €)	-5 %	-10 %	-20 %
	Amount of deciduous trees	10% deciduous trees	20% deciduous trees	0% deciduous trees
Percentage of owners	All owners	63.9%	19.9%	16.2%
	Utility oriented forest owner/lover	85.9%	6.9%	7.2%
	Recreation oriented forest owner	42.3%	52.2%	5.5%
	Tradition conscious forest owner	10.9%	0.3%	88.8%

Fig. 6. Worst-case scenarios, projecting the most disadvantageous levels of all attributes. The preferred management strategy per segment is highlighted in grey.

52% of recreation oriented forest owners the strong procedure, 89% of tradition conscious forest owners tend to select no procedure, hence neglecting forest management. With the information provided in the questionnaire and even under a worst-case scenario setting, 84% of forest owners would select some sort of management over no procedure (16%).

In general, these findings indicate that management procedures are not generally rejected by small-scale private forest owners as a whole but that it is rather a more intricate issue.

For an information campaign, it would be crucial to foresee the different impacts of arguing in favor of a desired or achievable condition in 50 years or for potential current benefits such as attractive offers yielding a positive balance after a procedure. The comparison between a “best-case in 50 years scenario” and the “best current management scenario” revealed a nearly identical relevance for the utility oriented (88.1 vs. 82.7% in favor of the soft procedure) and the recreation oriented forest owners (65.9 vs. 65.5% in favor of a strong procedure). The most interesting results are those related to the “do-nothing option”. Only if the overall outcome in 50 years will be highly undesirable, due to significant economic losses and a small amount of deciduous trees, the incentives and positive framing conditions under the “best management option scenario” become so attractive, that only 4.5% of all respondents remain inactive. Nearly all of those inactive owners belong to LC 3; the tradition conscious forest owners. Even the strongest incentives and most desirable management options have very

limited effect on their behavior, resulting in 26.8% still opting for the “do-nothing” scenario. These owners can only be mobilized by a long-term positive outcome projecting stable mixed stands and no loss in value. In this “best case in 50 years-scenario” only 3.4% of LC 3 preferred no procedure, while surprisingly, the majority selected a strong procedure (65.5%). Those results suggest that anticipated information campaigns should rather focus on achievable goals and attractive, stable forest stands with a diverse tree species composition resilient to climate change than on services, service providers, and possible offers.

In order to test the role of tree species composition and subsequently the potential impact of esthetics, the desired outcome in 50 years was analyzed in more detail. In a situation with little funding and the most preferred equipment and operational services available, all three segments react positively to an increase in deciduous trees in the future. Starting from the initial situation of 20% deciduous trees after the soft and the strong procedure, deciduous trees in the strong procedure were increased to the maximum of 40%. This significant increase solely attracts the recreation-oriented forest owners. While the percentage of LC 2 selecting this management strategy increases from 65.3% to 81.9%, the other two classes are impacted negatively and turn away from the strong procedure. LC 1 more frequently selects the soft procedure (92.1%), while LC 3 is even further inclined to undertake no procedure (65.8%) (Fig. 7). Even if the soft procedure would yield even < 20% deciduous trees, LC 1 remains in favor of this management strategy (> 90% support). Despite the severe impact on the increase of

		Forest management scenario		
Current decision	Intensity of procedure	Soft procedure predominantly natural regeneration	Strong procedure predominantly regeneration through planting	No procedure
	Balance after procedure	0 €	0 €	---
	Funding	1,000 €	1,000 €	---
	Type of procedure	Tractor	Tractor	---
	Commissioned by	Regional or local forest enterprise	Regional or local forest enterprise	---
Condition in 50 years	Probability of climate change induced damages	Very low	Low	High
	Potential change in value (estimate baseline 40.000 €)	0 %	0 %	0 %
	Amount of deciduous trees	20% deciduous trees	20% deciduous trees	3% deciduous trees
Percentage of owners	All owners	65.5%	25.4%	9.0%
	Utility oriented forest owner/lover	92.1%	4.8%	3.1%
	Recreation oriented forest owner	17.1%	81.9%	1.0%
	Tradition conscious forest owner	33.9%	0.3%	65.8%

Fig. 7. Preferences for management scenarios fostering deciduous trees.

deciduous trees on LC 3, they still play a minor role. Assuming a complete decline of deciduous trees due to no measures from 3% to 0% causes approximately 20% of LC 3 to opt for one of the management procedures. However, 42.1% of LC 3 would still choose not to perform measures. The experiment inherently suggests a positive impact of deciduous trees despite their introduction requiring effort and money.

As the share of deciduous trees is particularly important for LC 2 it was tested if this attribute is able to compensate negatively impacting attributes. The analysis indicated, that an increase of deciduous trees to 40% can raise acceptance of the threatened harvester (+ 6.4% from initial situation) and both rejected service providers (+ 10.9% Federal Forests service, and 6.4% environmental organization). However, even the 40% increase will not compensate a combined application of rejected attribute levels (− 1.1% and − 6.6% from initial situation).

Based on the findings, it is highly recommended that the information campaign and its promotion material paint a picture of a natural tree composition with a large amount of deciduous trees in owners' future forests.

4.5. Key issues regarding the development of advisory services

As indicated above, advice provided to small-scale private forest owners, particularly the utility oriented segment, should primarily build upon the promotion of a soft procedure with natural regeneration and a future vision of achieving mixed stands. However, any advisory service will most likely focus on owners' current decisions rather than

the outcome in 50 years. Therefore, it is crucial to understand the impacts of the different attributes shaping the current decision. Beside financial support, which is discussed in the next section, the selected equipment and service provider commissioned are of significant relevance.

About 90% of utility oriented forest owners opt for a soft procedure which fetches a zero balance, receives 1000 € funding, and is carried out with smaller, less impacting technical equipment. If the same procedure is commissioned by the Austrian Federal Forests service, the preference decreases by 5% and declines even further to a total preference of 69.2% if a harvester is utilized. Even if the last procedure would yield a positive balance of 500 €, the high revenue is not able to compensate the rejected equipment and service provider (Fig. 8).

The same effects can be observed in recreation oriented forest owners. The owners' preference for the strong procedure decreases from 65% to 51% if a harvester is utilized and further to 42% when the Federal Forests service performs the procedure. In the last case, the recreation oriented forest owners would even choose the weak procedure over the strong procedure. Even a high revenue of 1000 € from thinning has only a minor effect and increases acceptance to 48%.

Disliked service providers and equipment significantly increase the amount of forest owners selecting no procedure. Despite high revenue, 19% of the whole sample would refuse forest management measures.

These findings suggest that advice provided to small-scale private forest owners needs to convey, that all forest measures are performed with special care and under consideration of the remaining forest and

		Forest management scenario		
Current decision	Intensity of procedure	Soft procedure predominantly natural regeneration	Strong procedure predominantly regeneration through planting	No procedure
	Balance after procedure	500 €	0 €	---
	Funding	1,000 €	1,000 €	---
	Type of procedure	Harvester	Tractor	---
	Commissioned by	Service Team or Austrian Forest Service	Regional or local forest enterprise	---
Condition in 50 years	Probability of climate change induced damages	Very low	Low	High
	Potential change in value (estimate baseline 40.000 €)	0 %	0 %	0 %
	Amount of deciduous trees	20% deciduous trees	20% deciduous trees	3% deciduous trees
Percentage of owners	All owners	47.4%	36.7%	15.9%
	Utility oriented forest owner/lover	70.9%	20.1%	9.0%
	Recreation oriented forest owner	21.0%	76.8%	2.3%
	Tradition conscious forest owner	4.0%	0.5%	95.5%

Fig. 8. Impact of advisory services on the preference of management strategies.

that each stand is treated individually with adequate and small equipment. The advising service needs to be aware that the resilience of the stand, a treatment without obvious visual impacts, and an increase in specie composition is more important to the new forest owners than a guaranteed positive balance after the procedure. Since the results show a significant mistrust towards different managing organizations, this issue needs to be addressed beforehand through image campaigns and/or tailor-made offers pledging soft and sustainable harvesting and tending.

4.6. Key issues regarding possible payments and subsidies

Payments for the provision of certain ecosystem services are highly popular by governmental bodies to steer the overall development (Prokofieva, 2016). In order to verify this assumption, the impact of funding was tested for both procedures. Generally speaking, funding bears the potential to mobilize forest owners, in particular those owners intending not to perform climate change adaptation measures. However, the amount of funding itself needs to be irrationally high to achieve mobilization. Raising payments for the soft procedure from 1000 to 5000 € causes 12.8% of LC 3 to undertake measures and 8.0% of LC 2 to prefer the soft over the previously selected strong procedure. These shares are reduced to 2.5 and 0.7% respectively, if funding only amounts to 2000 €. In addition, increasing funding for the strong procedure to 5000 € has little to no effect on the three classes and barely

increases the procedures' preference (LC 1 + 3.9%, LC 3 + 0.1%). Therefore, it can be concluded that funding will not be feasible and at current rates not able to motivate small-scale private forest owners to undertake climate change adaptation measures. Overall, increasing funding for soft procedures is only suitable to mobilize 2.0% of all forest owners (90.5% apply a measure in initial situation, 92.5% after payments). In addition, increasing funding in either procedure does not outweigh the negative utilities from other attributes such as harvester use or the commissioning of the Austrian Federal Forests service.

4.7. Monetary benefit strategy

The monetary benefit strategy analysis investigates if a gain after the procedure may motivate participants to perform climate change adaptation measures. In general, a gain from the applied procedure is perceived as positive, yet, the impact of a positive balance is far less striking than expected. While the net profit in the soft procedure mobilizes an additional 6.2% of LC 2 and none of LC 3, a 1000 € balance after the strong procedure only sways an additional 5.3% of LC 2 to select this procedure. Owners in LC 3 unchangeably prefer no procedure and net gains alone cannot alter this preference. In fact, a negative balance after the soft procedure has barely any effect on the classes' preferences.

Even if both procedures yield a positive balance and receive funding of 5000 €, the percentage of participants performing climate change

adaptation measures only increases to 93.4% (from initially 83.8%). This overall increase of < 10% from the worst-case situation indicates once more, that monetary strategies are not the major driving factors for small-scale private forest owners to commission procedures in their forests.

5. Discussion

5.1. Small-scale private forest owners

Small-scale private forest owners are not homogenous. The overall results of this study concur with the broad findings in this field as small-scale private forest owners were found to be highly distinguishable through multiple aspects (e.g. Kvarda, 2004; Hogl et al., 2005; Weiss et al., 2007; Weiss et al., 2010; Weiss et al., 2015; Živojinović et al., 2015). However, several differences exist when the forest owner of this study were compared in more detail to the existing literature. For example, the sample was found to be fairly well informed about their forests including size, tree species composition, age of the forest, and current state of management, such as a definition as “alienated forest owners” cannot be fully supported. The owners’ surprisingly regular visits to their forest may be explained through a theory by Hujala and Tikkanen (2008) who argue, that living close to ones’ forest in their childhood will create psychological attachment. Such ties may account for this unexpected trend. However, the study can still confirm a negative correlation between an increasing distance from ones’ forest and the number of forest visits.

In terms of motivation for forest ownership, this study found patterns, which have been described in previous national and international (e.g. Truax et al., 2015) research. For instance, the mostly equal ratings of emotional motives indicate that forest owners may have more and also more diverse objectives to own forest as likewise described by Liubachyna and Wajchman (2015). In addition to “a good feeling”, “preserving family tradition” is one of the main motivations for forest ownership. Further analysis revealed that current owners are very unlikely to sell their property (only 0.4% contemplates a sale) and rather aim to bequeath these valuable properties themselves. The high importance of family tradition was also pointed out by Matilainen et al. (2015) who interviewed 23 forest owners around Europe. The importance and impact of family tradition became clearer as multiple participants indicated a forest ownership over 100 years (max. 400 years), thereby incorporating their ancestors and heritage into their own ownership and feeling ownership cross-generationally. These strong ties may also explain the “careful” decision making in the CE. The impression arises, that forests are often treated as possessions that may function as a liability rather than a commodity, yet, this further supports the strong influence of family tradition as forest is rather bequeathed than sold.

Comparing the results of this study to Matilainen et al. (2015) who, based on an extensive literature review, created a concise table projecting the differences between traditional and non-traditional forest owners reveals, that this sample, and each of the three established sub-samples, exhibits characteristics linked to both owner groups. Hence, it can be widely agreed that it is “almost impossible to characterize one

Adaptation measures	On-going measures	Planned measures
Forest regeneration (selection of tree species or provenance better adapted or adaptable to the changing climatic conditions)	- Select indigenous tree species and provenances - Select tree species that perform well across sites - Select tree species that can develop into stable diversified forests - Mix different tree species, provenances and genotypes	Use more natural regeneration Select tree species and provenances that are more resistant to temperature extremes Select fast-growing tree species
Tending and thinning (frequency and intensity of treatment after establishment or regeneration and before final harvest)	- Change silvicultural systems and thinning intensity to reduce risks of abiotic disturbances - Forbid thinning or change silvicultural systems in special conditions (e.g. risk of erosion rock fall or avalanches) - Change thinning methods for mixed and multistory forests	Change thinning schedule and intensity to decrease risks of abiotic disturbances Change thinning schedule for biomass harvesting Use specific management for the forest edges to avoid risks of abiotic disturbances Change management of stand for more stable and diverse stand structure Change thinning intensity in the most sensitive areas
Harvesting	- Modify harvesting procedures - Improve harvest equipment and tools for wet conditions - Use small-scale cutting areas - Execute sustainable harvesting	Prefer selective cutting

Fig. 9. Adaptation measures on the stand level. Measures deemed highly desirable by small-scale private forest owners are highlighted (changed after EFI, 2008).

forest owner as traditional or nontraditional by using strict “threshold characteristics” (Matilainen et al., 2015). This assumption underlines that the segmentation and characterization of forest owners (here by a latent class analyses) based on their management behavior and preferences rather than on predefined characteristics has the potential to define a new state of the art.

5.2. Forest management strategies and climate change adaptation

Concerning climate change and its possible impacts, the majority of forest owners is aware of the issue and either already recognizes first effects or expects future consequences. The overall awareness level is similar to other studies (e.g. Pröbstl-Haider et al., 2013). In terms of adaptation measures, about half of the participants recognized the need for action. However, various research findings show that the connection between knowledge and action is not necessarily given (Renkl, 1994) and that this knowledge can only be transferred into action if adequate incentives favor implementation, targeted offers facilitate the implementation, and the implementation of measures coincides with personal values (intrinsic motives) (Hoffmann et al., 2011; Beck et al., 2013). The findings of this study present guidelines to increase the acceptance of new strategies and planned advisory services.

Overall, climate change adaptation through tailored forest management is highly supported by the presented findings. Fig. 9 draws back upon the EFI (2008) suggestions and highlights those adaptation measures, which are deemed highly desirable based on the choice experiment. The figures show, that the guidelines provided by EFI (2008) are mostly in line with forest owners expectations.

The findings reveal a certain preference for a soft over a strong or no procedure and a considerable distrust towards technologically advanced forms of forest management such as harvesters, which are employed in approximately 20% of logging activities with a rising tendency (Nemestóthy, 2011). A strong preference for regional service providers emerged, underlining the importance of these local structures, while the service unit of the Austrian Federal Forests was clearly rejected.

Tailor-made forest management bears the advantage that it may consider the preferences of the three different segments found in this study. While the “utility oriented forest owner” seems to reject significant forest management actions and reacts sensitive towards harvesting methods and the selected enterprises, the “recreation oriented forest owner” tends to follow a long-term approach by preferring a strategy, which significantly enhances broadleaf trees. About 66% of the tradition conscious forest owners refuse any type of procedure and only considers the adaptation of a different strategy at maximum losses. Mobilizing these owners remains one of the most crucial future tasks.

In Austria, new forest management approaches - particularly when related to small or fragmented forests - are predominantly discussed from a wood mobilization point of view. The traditional forest management approaches envisioned, and in particular those offered by state-owned institutions, are viewed critically by all owner types alike, making a proper applicability of standardized expert based forest models, build upon growth and use potential, very unlikely. Against the backdrop of the findings, a severe need to deviate from past and current performances and management strategies emerges, which requires targeted initiatives that can provide sufficient incentives for action. As Weiss et al. (2015) state, so far no forest management approaches were identified which would be specifically applied by “new” forest owners. Therefore, this study discussed different management strategies as well as strategies for information and an advisory service. Many recommendations provided are supported by the literature including

- the outstanding role of diversification and the preferred increase of deciduous trees (Schaich and Plieninger, 2013; Hanewinkel et al., 2012),
- the limited impact of payments and funding (Prokofieva, 2016),
- the relevance of the time lack between the activity and its outcomes, the related need to communicate the impact of inaction on forest values (Matthes et al., 2014),
- the increasing relevance of networks and support for forest owners (Weiss et al., 2006),
- the need for a shift away from terms such as “timber mobilization” in the communication with small-scale private forest owners to new terms such as “increasing resilience and stability” (Schaffner et al., 2014), and
- the necessity for tailor-made advisory service, which are able to address specific concerns such as climate change adaptation and engage new user groups like female forest owners (Follo et al., 2016; Umaerus et al., 2016).

The presented results particularly contradict those studies in the field of climate change adaptation and wood mobilization (e.g. Setzer, 2006, proholz.at), which perceive payments and monetary benefits from timber sales as the key steering instrument. This perception might hold up for larger forest units, however most private forests owners do not follow the proper logic of larger forest enterprises. For those owners, the forest itself and its future state are highly relevant - values, which are mostly unaffected by incentives. Therefore, incentives are of less relevance, particularly when it comes to funding and payment, which ultimately increases the importance for addressing the emotional component of these forest owners. Hence, effective forest management for climate change must be responsive to a wide variety of economic, social, political and environmental circumstances simultaneously (Spittlehouse and Stewart, 2003).

6. Conclusion

Decision-makers need to recognize that small-scale private forest owners require tailored informed about the challenges of climate change and adaptation in order to become re-active in forest management. The owners need to envision their own healthy, diverse forest with adequate and sustainable amounts of deciduous trees, which is managed gently by skilled local service providers.

Trying to engage owners, with a property smaller than 20 ha, through funding or other monetary incentives will not succeed, since these incentives seem irrelevant for this specific forest owner type. Future forest managers will need to be innovative to get in touch with this diverse target group and will be required to redefine the definition of appropriate forest management strategies for small-scale private forest owners in their respective institutions. In addition, tailored approaches for contacting these groups will be necessary to re-establish communication channels and trust.

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Model for Choices			All owners		
			R ²	0.0436	
			R ² (0)	0.2462	
Attributes			Estimates	s.e.	z-value
Soft procedure			1.0036	0.0488	20.5861
Strong procedure			-0.0719	0.0526	-1.3650
No procedure			-0.9318	0.0442	-21.0726
Soft procedure	Balance after procedure	-500 €	-0.0447	0.0452	-0.9894
		0 €	-0.0361	0.0439	-0.8212
		500 €	0.0808	0.0457	1.7679
	Funding	1,000 €	-0.1095	0.0441	-2.4826
		2,000 €	-0.0274	0.0434	-0.6313
		5,000 €	0.1369	0.0447	3.0607
	Commissioned by	Regional or local forest enterprise	0.2266	0.0484	4.6865
		Environmental organization	-0.1714	0.0590	-2.9063
		Forest management unit	0.0952	0.0603	1.5773
		Service team or Austrian Forest Service	-0.1503	0.0491	-3.0626
	Type of procedure	Harvester	-0.3689	0.0421	-8.7609
		Tractor	0.2590	0.0447	5.7883
		Manual operation	0.1099	0.0423	2.6010
	Potential change in value	-5%	-0.1072	0.0427	-2.5116
		0%	-0.0088	0.0427	-0.206
		10%	0.116	0.0417	2.779
	Amount of deciduous trees		0.1013	0.0328	3.0853
Strong procedure	Balance after procedure	-1,000 €	-0.1990	0.0510	-3.9063
		0 €	-0.0104	0.0446	-0.2338
		1,000 €	0.2095	0.0454	4.6107
	Funding	1,000 €	-0.0848	0.0454	-1.8672
		2,000 €	-0.0890	0.0452	-1.9706
		5,000 €	0.1738	0.0443	3.9209
	Commissioned by	Regional or local forest enterprise	0.2117	0.0509	4.1629
		Environmental organization	-0.2044	0.0673	-3.0361
		Forest management unit	0.0561	0.0635	0.8835
		Service team or Austrian Forest Service	-0.0634	0.0538	-1.1782
	Type of procedure		0.3097	0.0329	9.4066
	Potential change in value	-10%	-0.2340	0.0446	-5.2486
		0%	0.0215	0.0432	0.4976
		10%	0.2125	0.0457	4.6494
	Amount of deciduous trees	20% deciduous trees	-0.0816	0.0457	-1.7861
		30% deciduous trees	-0.0297	0.0458	-0.6480
		40% deciduous trees	0.1112	0.0452	2.4629
No procedure	Potential change in value	-20%	-0.1802	0.0773	-2.3300
		-10%	-0.0890	0.0729	-1.2202
		0%	0.2692	0.0722	3.7300
	Amount of deciduous trees	0% deciduous trees	-0.1363	0.0756	-1.8013
		1% deciduous trees	0.0186	0.0787	0.2359
		3% deciduous trees	0.1177	0.0701	1.6794

Appendix 1. 1-class latent class model results.

Model for Choices			Utility oriented forest owners/lovers			Recreation oriented forest owners			Tradition conscious forest owners			Overall			
R ² R ² (0)			0.0822 0.5969			0.0831 0.4168			0.1236 0.3811			0.4493 0.5659			
Attributes			Estimates	s.e.	z-value	Estimates	s.e.	z-value	Estimates	s.e.	z-value	Wald	p-value	Wald(=)	p-value
Soft procedure			2.1218	0.1172	18.1100	0.6345	0.1561	4.0635	0.8461	0.3061	2.7643	624.4052	0.0000	381.1863	0.0000
Strong procedure			-0.7014	0.1524	-4.6036	1.5651	0.1838	8.5154	-2.8750	0.5192	-5.5371				
No procedure			-1.4204	0.1342	-10.5821	-2.1995	0.2440	-9.0163	2.0289	0.2946	6.8867				
Soft procedure	Balance after procedure	-500 €	-0.1212	0.0906	-1.3380	-0.1126	0.1090	-1.0327	-0.0470	0.1921	-0.2445	5.3826	0.5000	1.0724	0.9000
		0 €	0.0211	0.0946	0.2227	-0.0788	0.1012	-0.7790	0.0548	0.1869	0.2930				
		500 €	0.1002	0.0991	1.0110	0.1914	0.1154	1.6586	-0.0078	0.1932	-0.0404				
	Funding	1,000 €	-0.1558	0.0937	-1.6633	-0.1269	0.1005	-1.2631	-0.2156	0.1862	-1.1583	13.0031	0.0430	1.2550	0.8700
		2,000 €	0.0236	0.0909	0.2598	-0.0984	0.1039	-0.9464	-0.1071	0.1893	-0.5654				
		5,000 €	0.1322	0.0985	1.3419	0.2252	0.0996	2.2624	0.3227	0.1839	1.7549				
	Commissioned by	Regional or local forest enterprise	0.3191	0.1030	3.0981	0.4164	0.1115	3.7355	0.4058	0.2115	1.9187	44.0524	0.0000	1.9709	0.9200
		Environmental organization	-0.3493	0.1141	-3.0604	-0.1888	0.1532	-1.2324	-0.3745	0.2621	-1.4290				
		Forest management unit	0.1583	0.1231	1.2866	-0.0525	0.1506	-0.3486	0.2345	0.2831	0.8282				
	Type of procedure	Service team or Austrian Forest Service	-0.1281	0.0955	-1.3406	-0.1751	0.1173	-1.4919	-0.2658	0.2280	-1.1660				
		Harvester	-0.6379	0.0868	-7.3516	-0.2354	0.1009	-2.3342	-1.0211	0.2232	-4.5750	90.9015	0.0000	16.4263	0.0025
		Tractor	0.3297	0.0928	3.5510	0.0543	0.1071	0.5073	0.7649	0.1940	3.9428				
	Potential change in value	Manual operation	0.3082	0.0940	3.2804	0.1811	0.0946	1.9151	0.2562	0.1753	1.4616				
		-5%	-0.1793	0.0915	-1.9588	-0.1274	0.1016	-1.2544	-0.1734	0.1899	-0.9134	11.3196	0.0790	2.0002	0.7400
		0%	0.0476	0.0899	0.5297	-0.0851	0.0987	-0.8630	0.1677	0.1853	0.9050				
		10%	0.1317	0.0879	1.4975	0.2125	0.0988	2.1508	0.0058	0.1799	0.0321				
	Amount of deciduous trees		0.0742	0.0678	1.0940	0.2835	0.0741	3.8268	0.0353	0.1460	0.2420	17.0638	0.0007	4.7516	0.0930
Strong procedure	Balance after procedure	-1,000 €	-0.2155	0.1103	-1.9543	-0.4210	0.1177	-3.5764	-1.0407	0.5902	-1.7633	27.1530	0.0001	2.8985	0.5700
		0 €	0.0218	0.0933	0.2333	0.0884	0.1122	0.7871	0.3873	0.4000	0.9682				
		1,000 €	0.1937	0.0988	1.9612	0.3326	0.1003	3.3175	0.6534	0.4359	1.4989				
	Funding	1,000 €	-0.1663	0.1005	-1.6551	-0.1580	0.0933	-1.6939	-0.0390	0.3895	-0.1002	23.6957	0.0006	2.5560	0.6300
		2,000 €	-0.1892	0.1016	-1.8612	-0.0204	0.0984	-0.2075	-0.4387	0.4330	-1.0132				
		5,000 €	0.3555	0.0917	3.8755	0.1784	0.0991	1.7996	0.4777	0.3532	1.3524				
	Commissioned by	Regional or local forest enterprise	0.2776	0.1060	2.6196	0.2670	0.1117	2.3908	0.1744	0.4154	0.4198	31.7346	0.0002	3.6918	0.7200
		Environmental organization	-0.5411	0.1579	-3.4273	-0.3082	0.1376	-2.2394	0.3486	0.5788	0.6024				
		Forest management unit	0.2881	0.1277	2.2556	0.1165	0.1441	0.8082	-0.8063	0.7258	-1.1109				
	Type of procedure	Service team or Austrian Forest Service	-0.0246	0.1230	-0.1999	-0.0752	0.1080	-0.6968	0.2833	0.5186	0.5462				
		Harvester	0.5576	0.0701	7.9575	0.2894	0.0794	3.6474	0.9369	0.2806	3.3389	100.8276	0.0000	9.1710	0.0100
		Tractor	-0.2612	0.0950	-2.7490	-0.3785	0.0931	-4.0665	0.0283	0.4130	0.0684	39.9134	0.0000	8.4302	0.0770
	Potential change in value	Manual operation	-0.0568	0.0927	-0.6125	0.1915	0.0949	2.0176	-1.0694	0.5081	-2.1047				
		-10%	0.3180	0.0981	3.2431	0.1870	0.1005	1.8601	1.0411	0.4401	2.3658				
		0%	0.2287	0.0943	2.4252	-0.4582	0.0983	-4.6615	0.0448	0.4318	0.1038	31.3995	0.0000	28.5124	0.0000
	Amount of deciduous trees	20% deciduous trees	-0.0904	0.0998	-0.9062	0.0403	0.1022	0.3940	0.1418	0.4213	0.3366				
		30% deciduous trees	-0.1382	0.0980	-1.4109	0.4179	0.1029	4.0632	-0.1866	0.4050	-0.4608				
		40% deciduous trees													
No procedure	Potential change in value	-20%	-0.2752	0.2072	-1.3279	-0.5602	0.4720	-1.1869	-0.2203	0.1724	-1.2781	15.5638	0.0160	0.9328	0.9200
		-10%	-0.2243	0.1976	-1.1351	0.1270	0.3939	0.3225	-0.1268	0.1814	-0.6992				
		0%	0.4995	0.1739	2.8726	0.4331	0.3873	1.1184	0.3471	0.1844	1.8829				
	Amount of deciduous trees	0% deciduous trees	0.0400	0.1988	0.2011	0.2896	0.4261	0.6795	-0.6249	0.1680	-3.7191	18.1496	0.0059	9.3899	0.0520
		1% deciduous trees	-0.3240	0.2432	-1.3323	-0.3181	0.5990	-0.5310	0.2794	0.2050	1.3631				
		3% deciduous trees	0.2841	0.1781	1.5951	0.0285	0.4200	0.0679	0.3455	0.1882	1.8364				

Appendix 2. 3-class latent class model results.

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